

LETTER

Valence state partitioning of V between pyroxene and melt for martian melt compositions Y 980459 and QUE 94201: The effect of pyroxene composition and crystal structure

JAMES J. PAPIKE¹, PAUL V. BURGER^{1,*}, AARON S. BELL¹, CHARLES K. SHEARER¹, LOAN LE², JOHN JONES³ AND PAULA PROVENCIO¹

¹Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131, U.S.A.

²JSC Engineering, Technology and Science (JETS), NASA Johnson Space Center, Houston, Texas 77058, U.S.A.

³NASA Johnson Space Center, Houston, Texas 77058, U.S.A.

ABSTRACT

A martian basalt (Yamato 980459) composition was used to synthesize olivine, spinel, and pyroxene at 1200 °C at five oxygen fugacities: IW-1, IW, IW+1, IW+2, and QFM. The goal of this study is to examine the significant variation in the value of $D_{\text{V}^{\text{pyroxene/melt}}}$ with changing Wo content in pyroxene. While most literature on this subject relies on electron microprobe data that assumes that if the Wo component (CaSiO_3) is <4 mol%, the pyroxene is in fact orthopyroxene, we've made a more robust identification of orthopyroxene using appropriate Kikuchi diffraction lines collected during electron backscatter diffraction analysis. We compare augite (Wo ~ 33), pigeonite (Wo ~ 13), orthopyroxene (Wo <4), and olivine. In augite (Wo ~ 33), the M2 site is 8-coordinated, while in pigeonite (Wo ~ 13), the site is 6-coordinated. The larger (8-coordinated) M2 site in augite requires structural expansion along the chain direction. The longer chain is enabled by the substitution of the larger Al for Si. The Al^{3+} substitution for Si^{4+} causes a charge deficiency that is made up, in part, by the substitution of V^{4+} and V^{3+} in the pyroxene M1 site. This rationale does not fully explain the dramatic decrease in $D_{\text{V}^{\text{orthopyroxene/melt}}}$. In monoclinic pyroxenes, the TOT stacking is characterized by + + + + (indicating the direction), a stacking pattern that produces a monoclinic offset. In orthopyroxene, the stacking is + + - -, which produces an orthorhombic structure. The M2 site is located between the reversed TOT units and is highly constrained to 6-coordination and thus cannot contain significant Ca that requires 8-coordination. Because the M2 site in orthopyroxene is small and constrained, it accommodates less Al in the tetrahedral chains and thus less V in the pyroxene M1 site.

Keywords: Vanadium, partitioning, pyroxene, orthopyroxene, augite, pigeonite, EBSD, valence